

*National Seminar
on
Moisture Sensitivity of Asphalt
Pavements*

**TOPIC 4
TREATMENTS**

Eric Berger
Jim Anagnos

February 4-6, 2003

Types of Treatments

- **Applied to Asphalt Binder**
- **Applied to Aggregate**

Applied to Asphalt Binder

- **Alkyl Amines (most common)**
- **Polymers**
- **Other Chemicals**

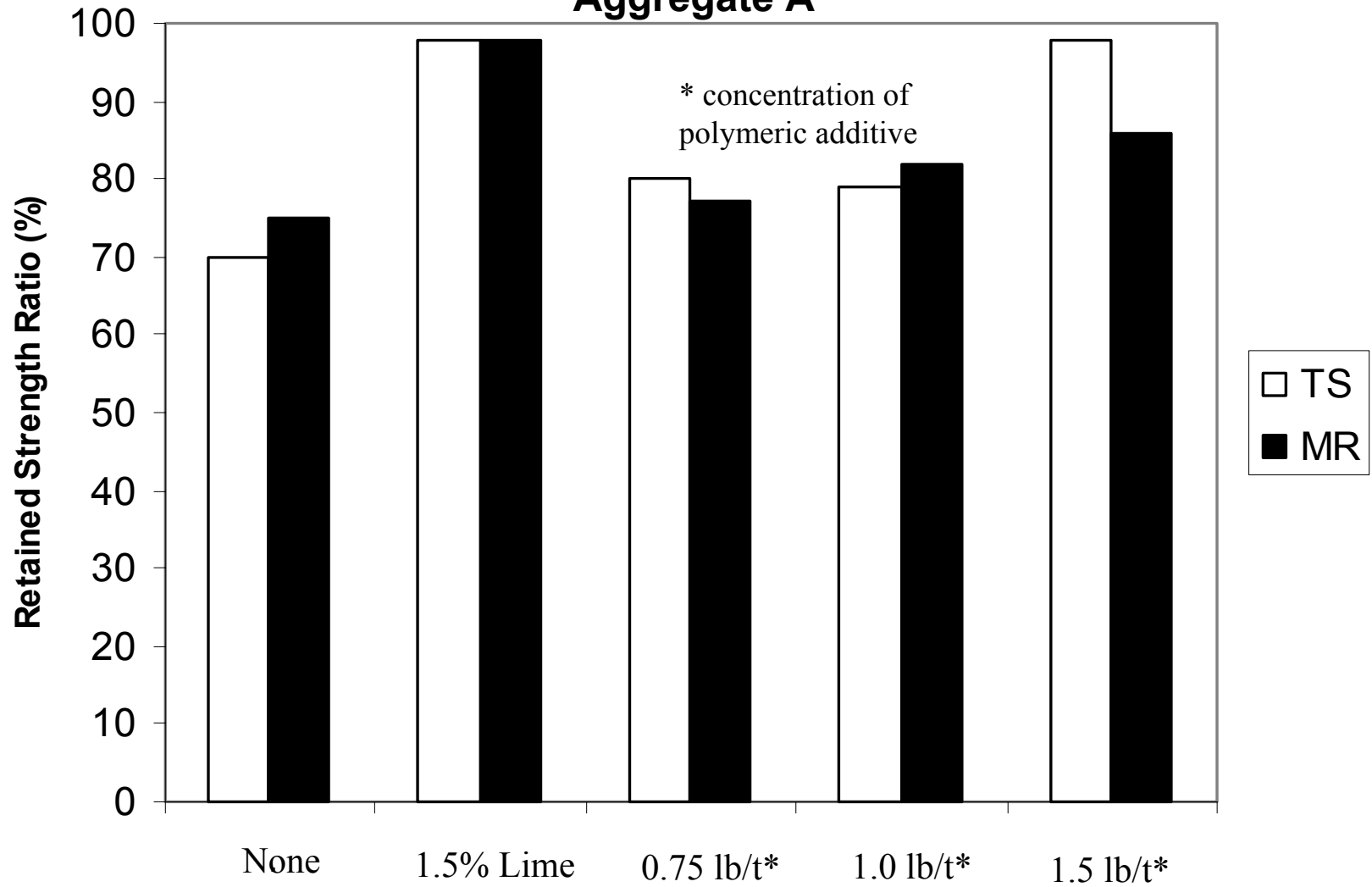
Applied to Aggregates

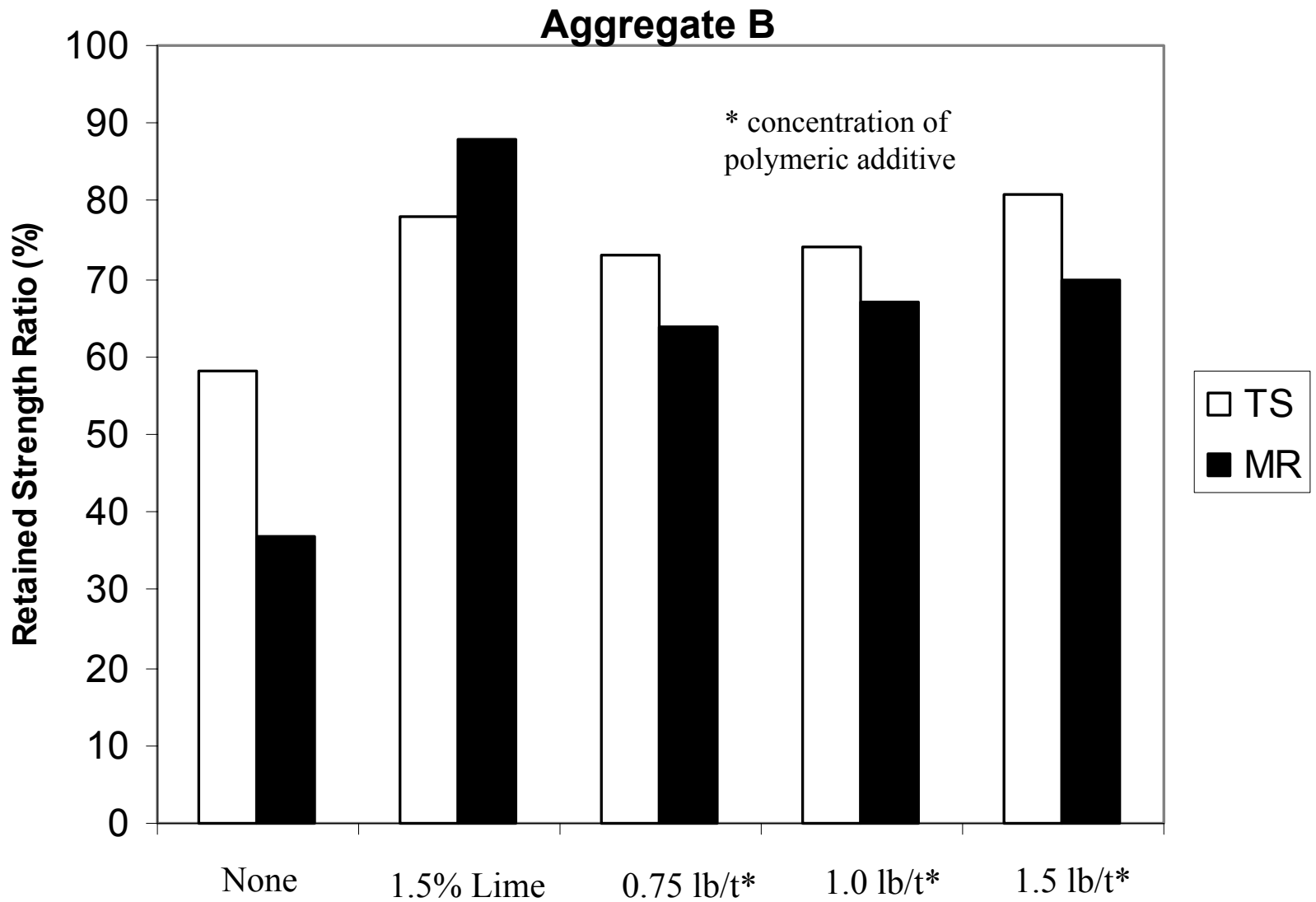
- Lime (most common)
- Portland Cement
- Fly Ash
- Flue Dust
- Polymers
- Other Chemicals

Polymers

- **Applied to Asphalt Binders**
- **Applied to Aggregates**

Aggregate A





Treatment Type Effectiveness

- Asphalt Binder Type
- Aggregate Type
- Concentration
- HMA Design
- Time and Temperature of Storage
- Test Method Used for Evaluation
- Short Term Properties
- Long Term Properties

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ASPHALT PAVEMENTS

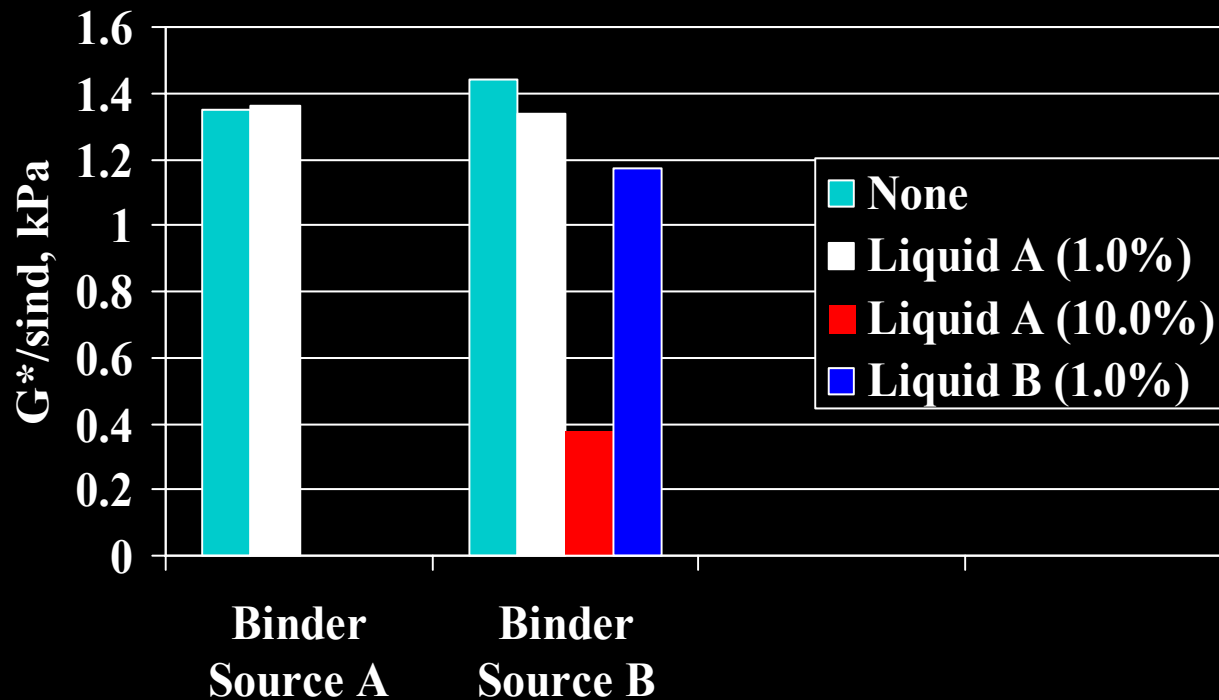
TOPIC 4
TREATMENTS

February 4-6, 2003
San Diego, California

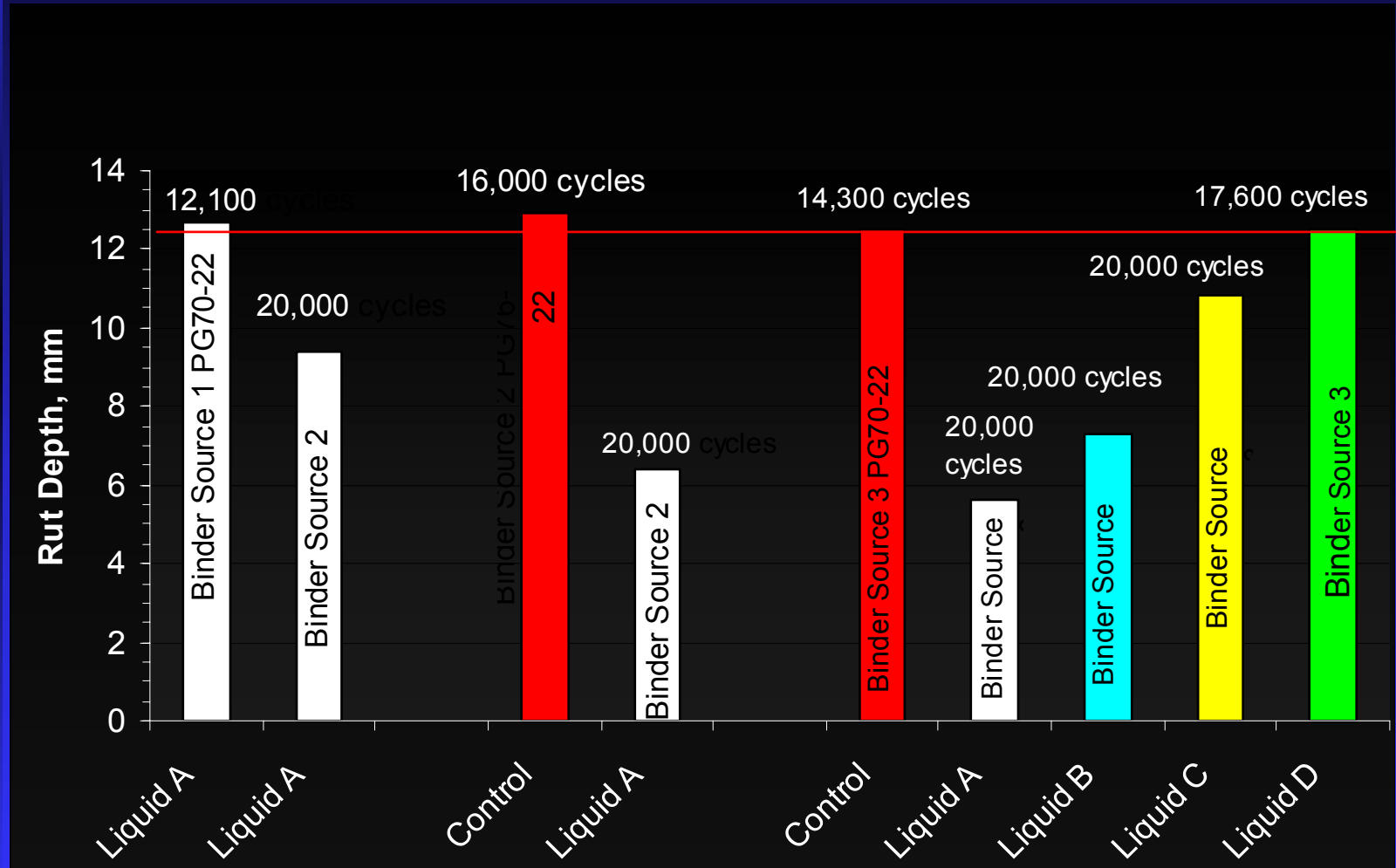
Treatment of Asphalt Mixtures with Liquid Anti-Stripping Agents

James N. Anagnos
Consultant
Akzo Nobel

SHRP DSR Binder Effect With High Performance Liquids



Hamburg Test Results @ 50°C

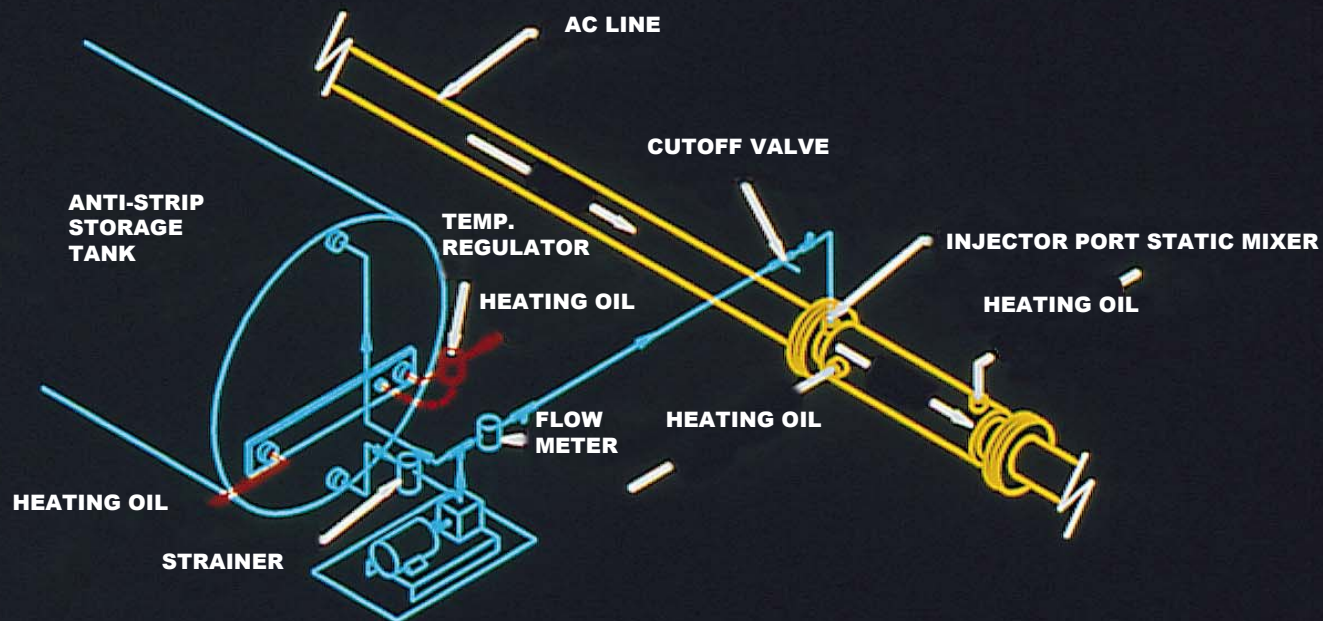


LAS

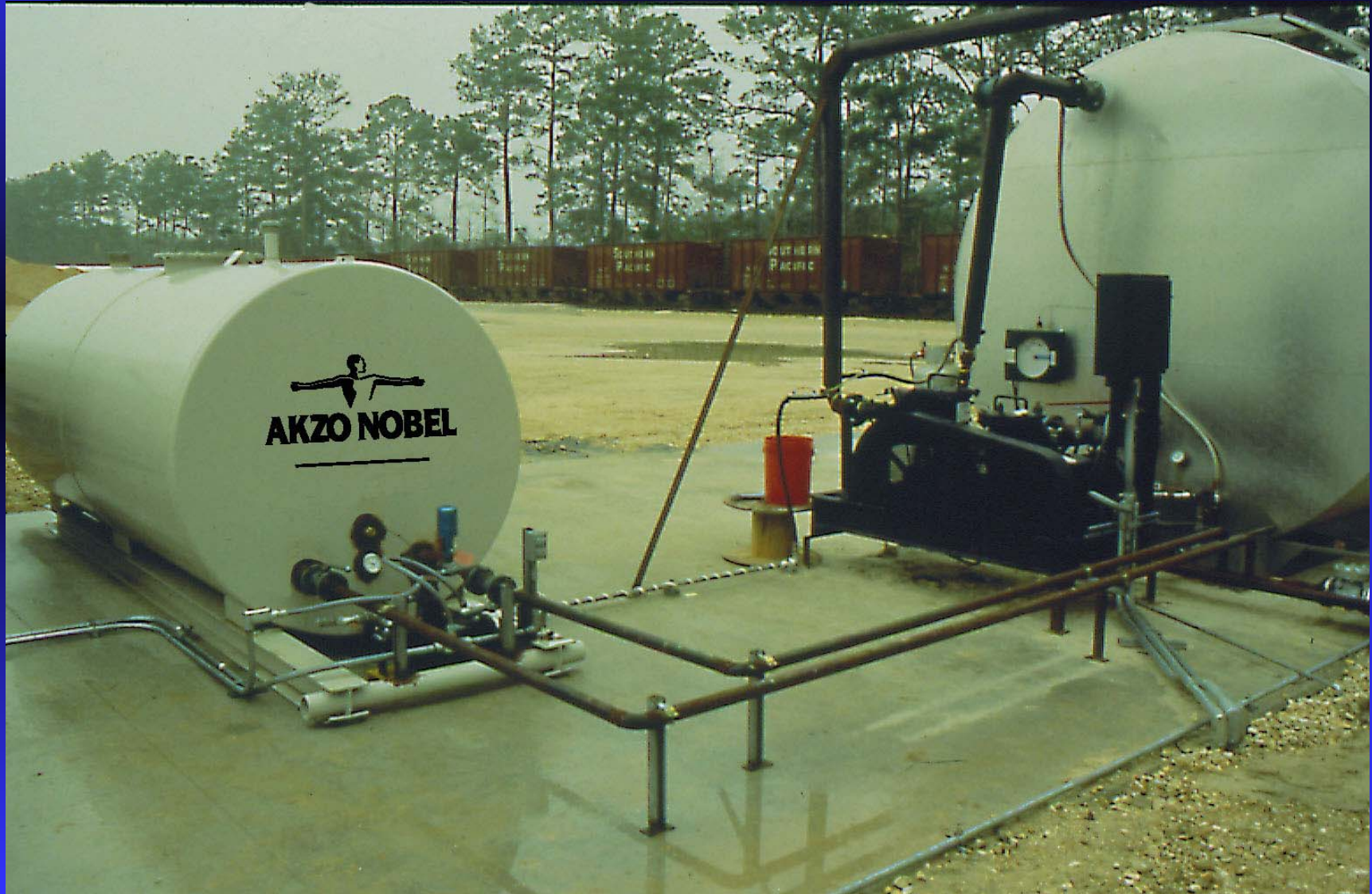
Applied to Asphalt Cement

- Refinery
- On-job-site

Block Diagram



Field System



Field System



Louisiana Field Study

- Location: LA 450
- Date Placed: July 1990
- Contractor: Barrier Construction
- Testing Agency: Barry Moore & Associates

Materials

- Aggregate: Crushed gravel
Local field sand
- Asphalt: Exxon AC-30
- Additives: LAS agents
Hydrated lime

Additives

■ Liquid A, %	0.8
■ Hydrated Lime, %	1.4
■ Liquid B, %	0.8
■ Liquid C, %	0.8
■ Lime/Liquid B, %	1.4/0.8

Louisiana Test Methods

- Ross Count
- Boiling Water
- Modified Lottman

Ross Count

- Plant mixed material
- Percent coating of +No. 4 agg.

Ross Count



Boiling Water Test

- Plant mixed material
- Boil 10-minutes in distilled water
- Drain and air dry
- Visually determine stripping

Typical Results



Fail



Pass

Modified Lottman AASHTO T283

- Freeze – Thaw Cycles
- One, Three, Five, and Ten cycles

Modified Lottman Parameters Evaluated

- Tensile Strength
- Tensile Strength Ratio
- Air Voids
- Visual Stripping after testing

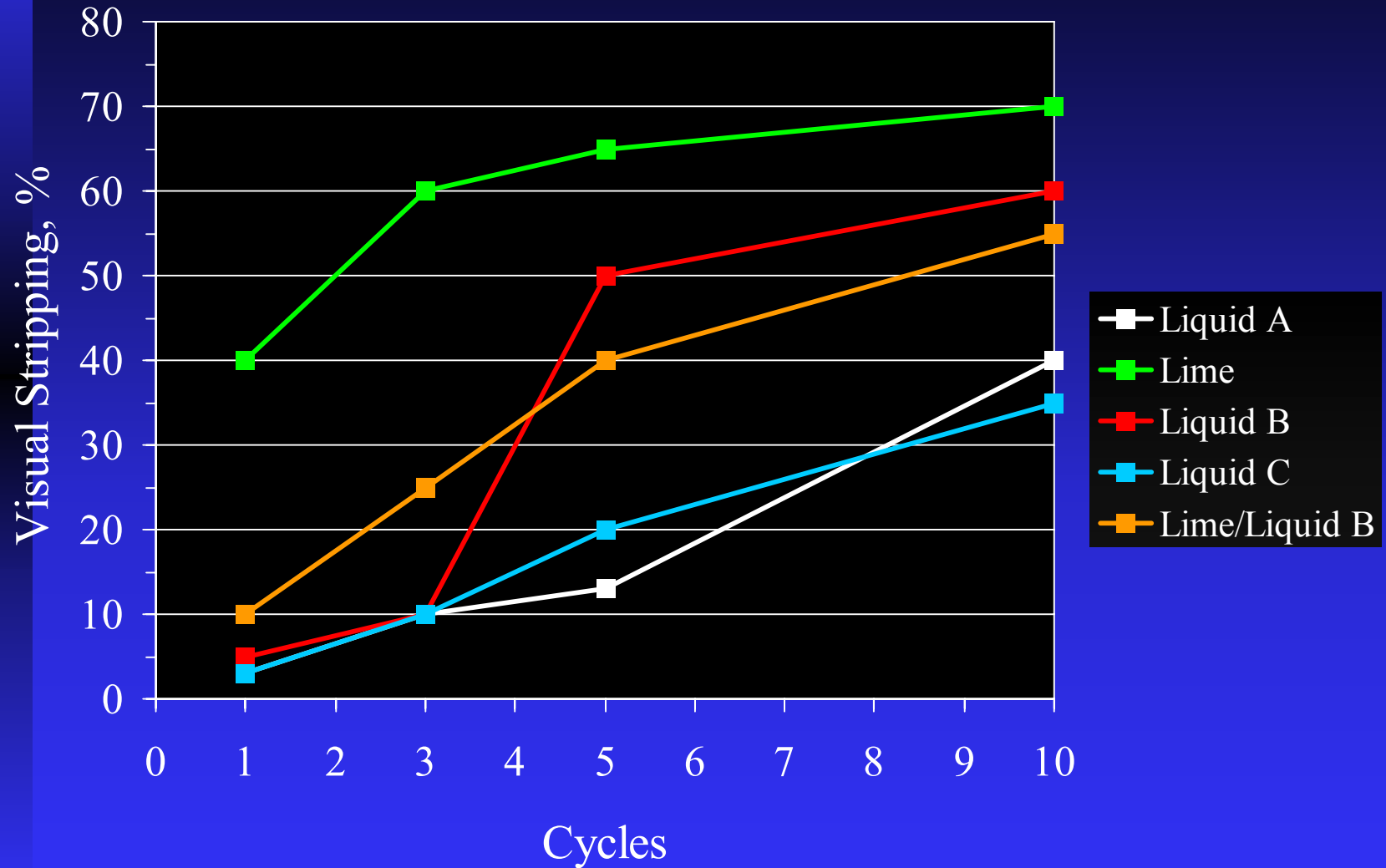
Typical Appearance



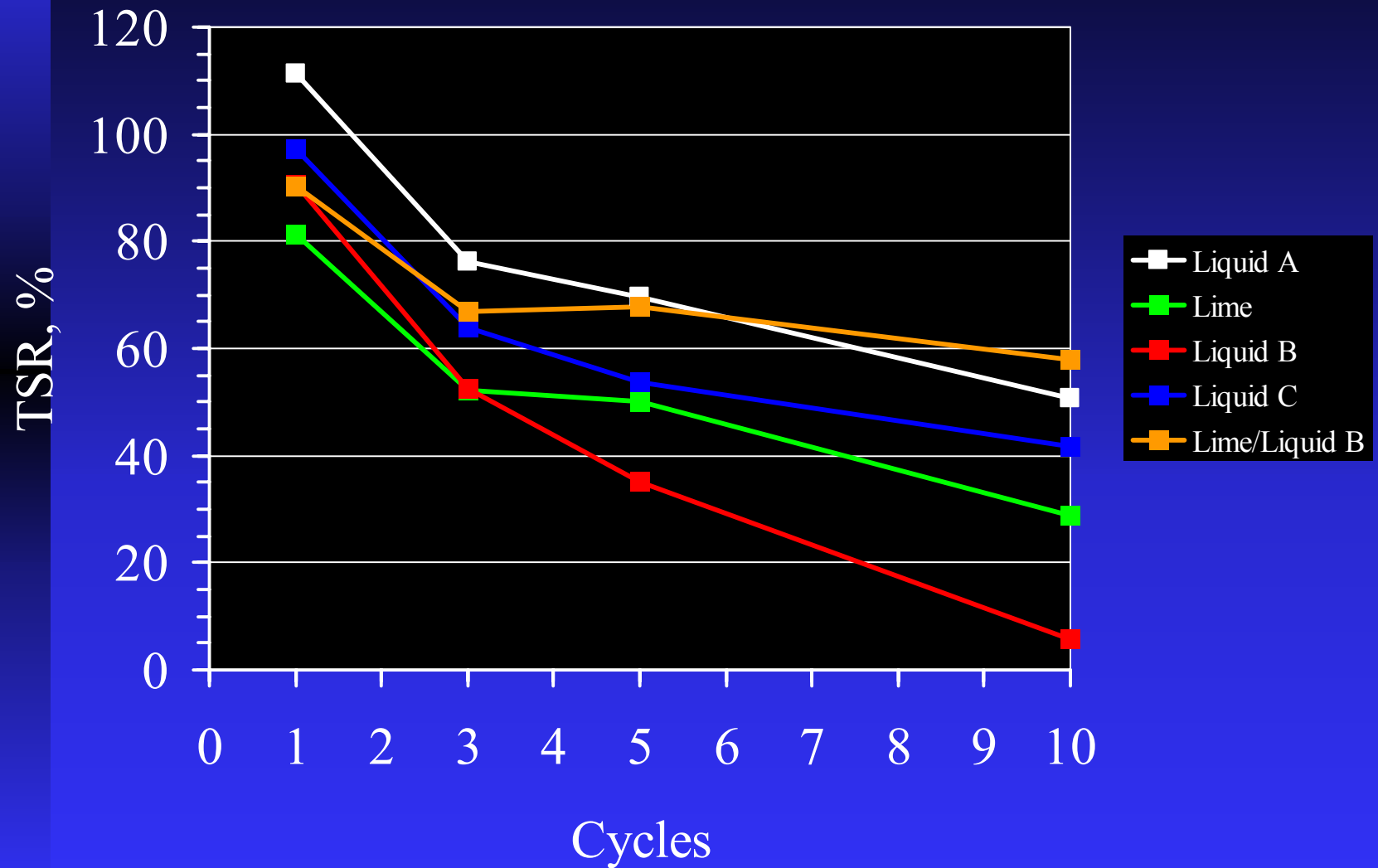
Fail

Pass

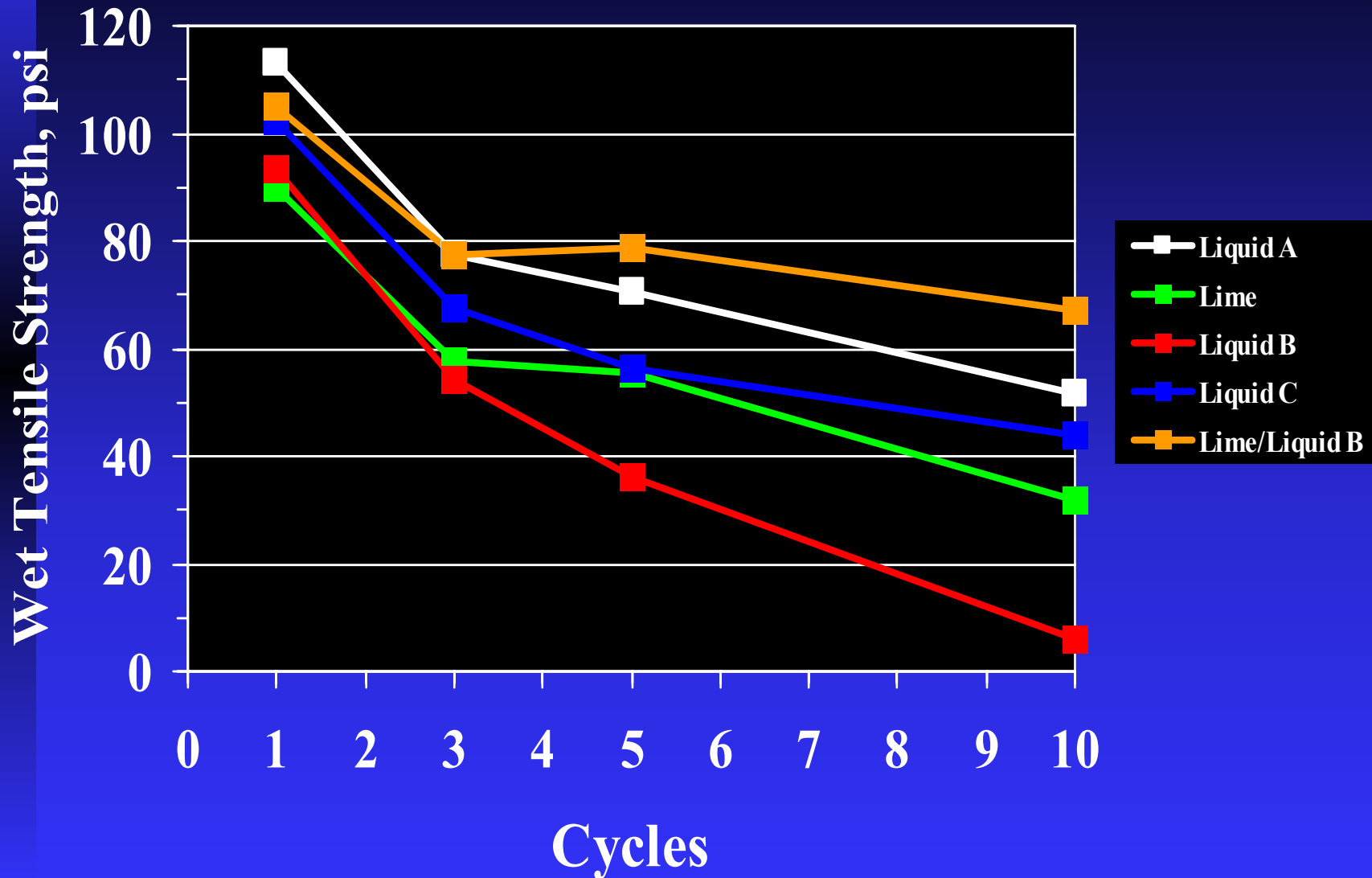
Visual Stripping vs Freeze-Thaw Cycles



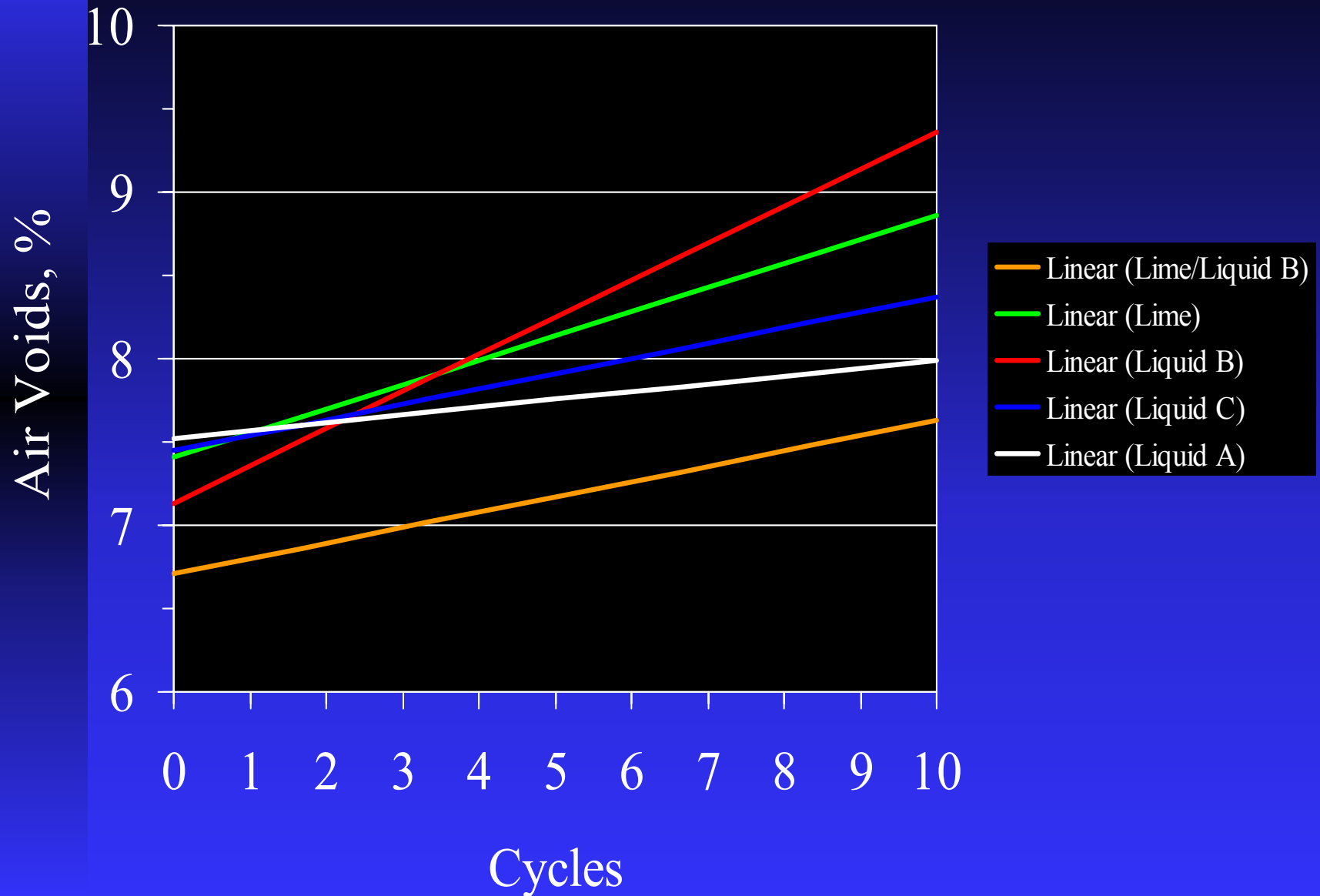
Tensile Strength Ratio vs Freeze-Thaw Cycles



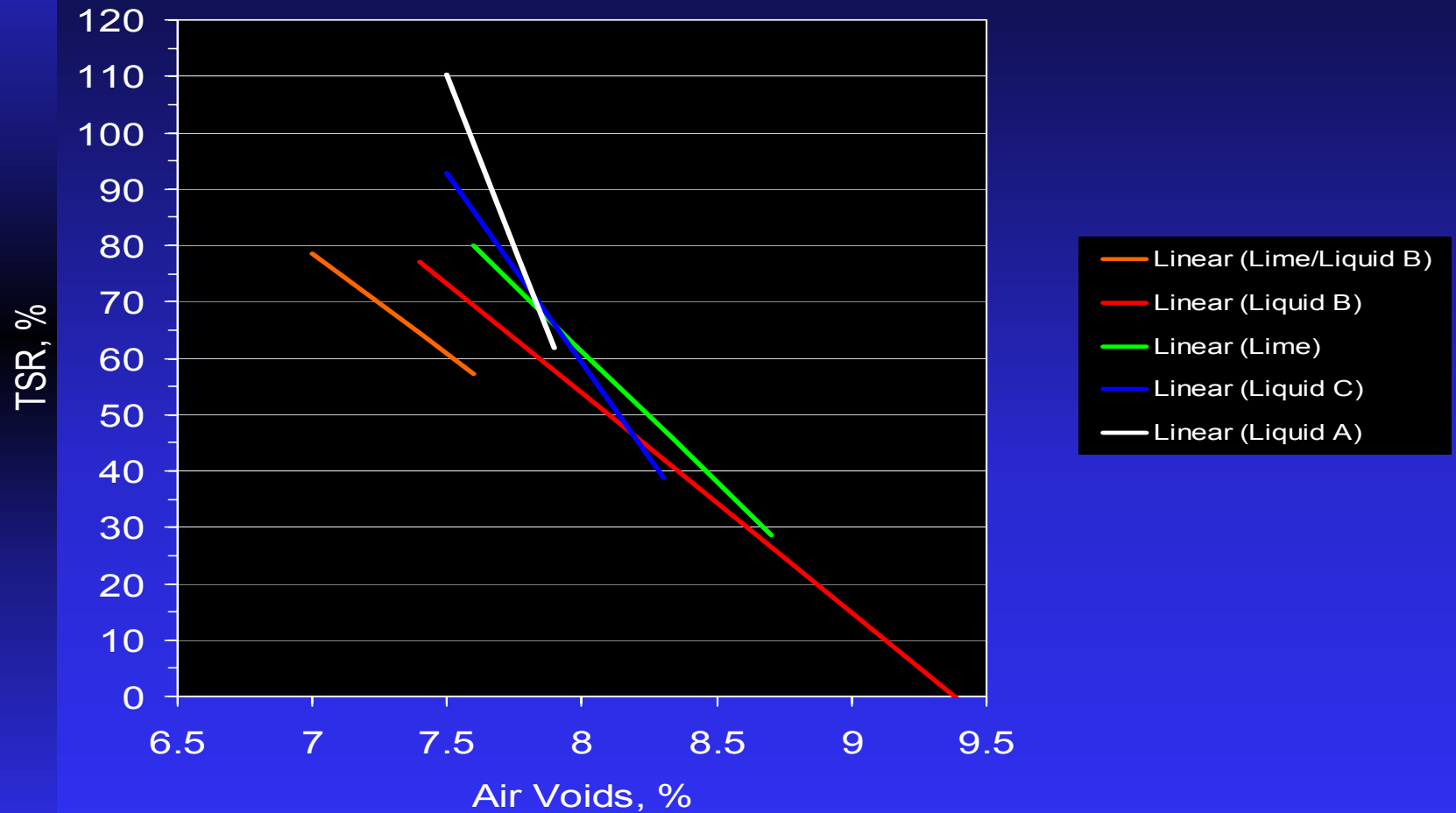
Wet Tensile Strength vs Freeze-Thaw Cycles



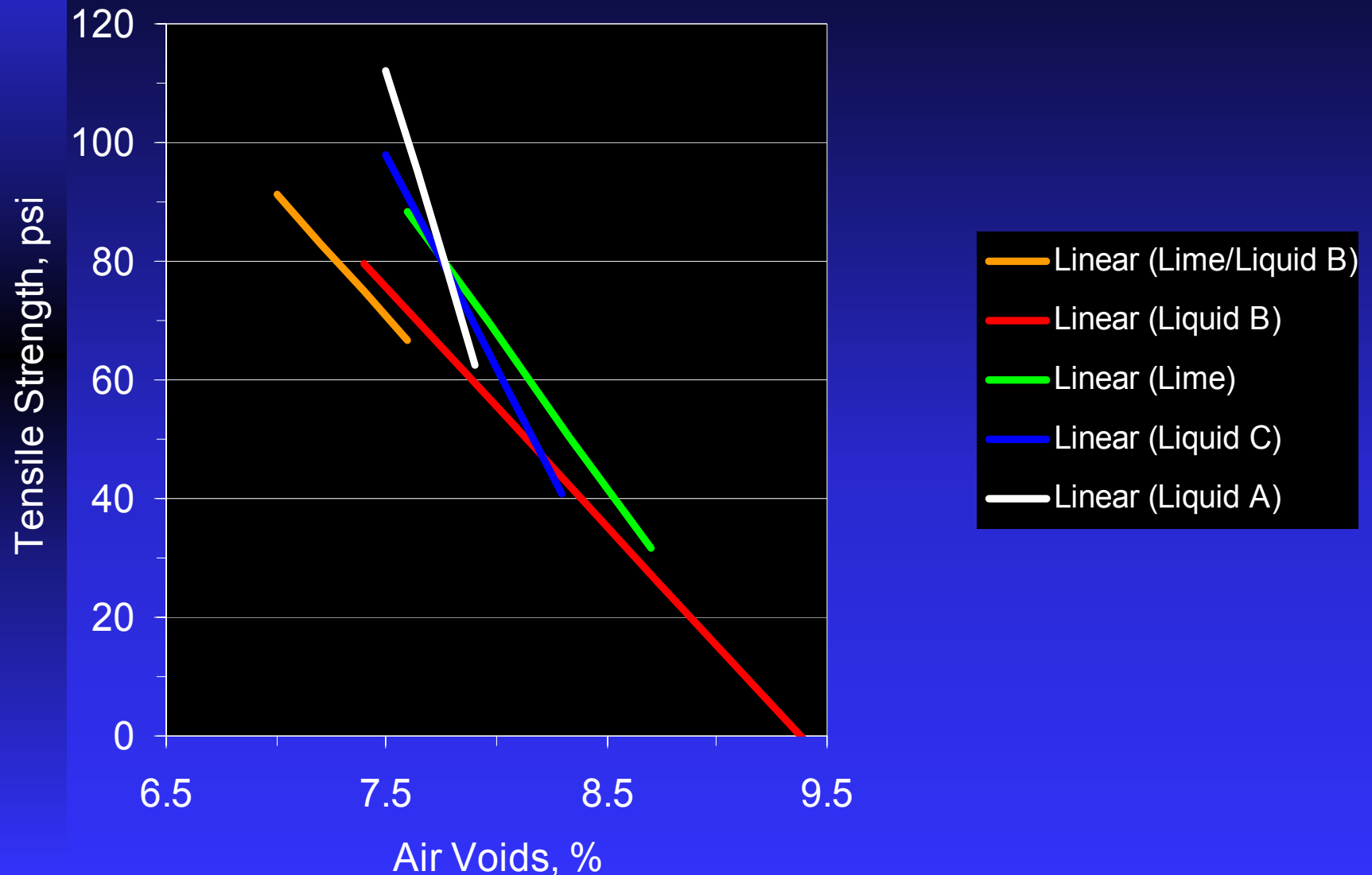
Air Voids vs Freeze-Thaw Cycles



Tensile Strength Ratio vs Air Voids



Tensile Strength vs Air Voids



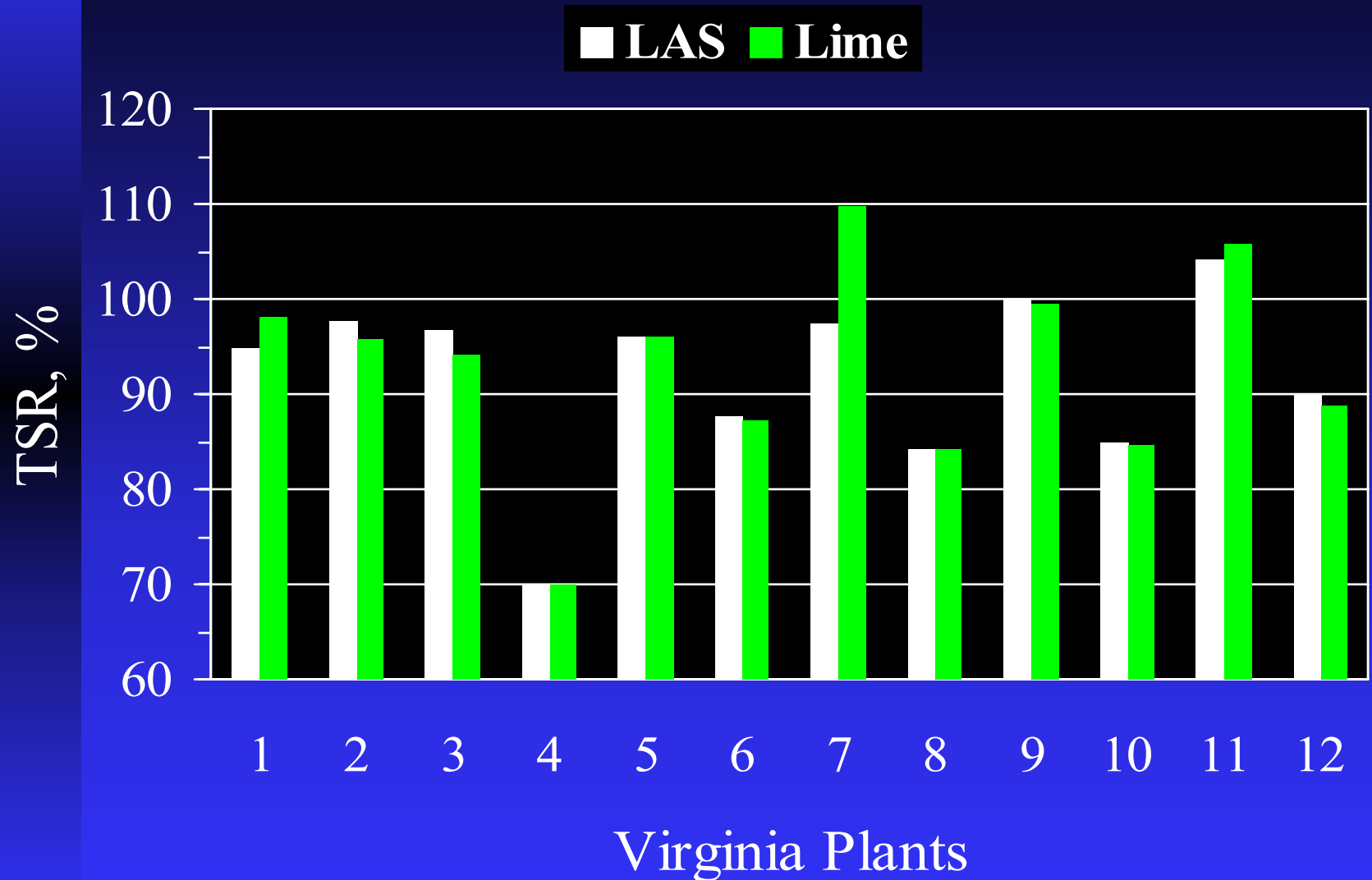
2001



Virginia Test Method for Moisture Damage

Root-Tunnicliff Version
of
Modified Lottman

Tensile Strength Ratio - Virginia



Costs

Liquid Anti-strip Agent

- \$0.45 to \$0.75 per pound of liquid or
- \$6.75 to \$11.25 per ton of asphalt binder or
- \$0.30 to \$0.70 per ton of hot mix

In-line Blending Equipment

- \$10,000 to \$25,000

Conclusions

Liquid Anti-stripping Additives

- Effective – high performance additives
- Easy to use
- Added at refinery or hot mix plant
- Minimal Cost - \$0.50 to \$0.80/ton of hot mix



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Topic 4
Treatments – Hydrated Lime

Eric Berger



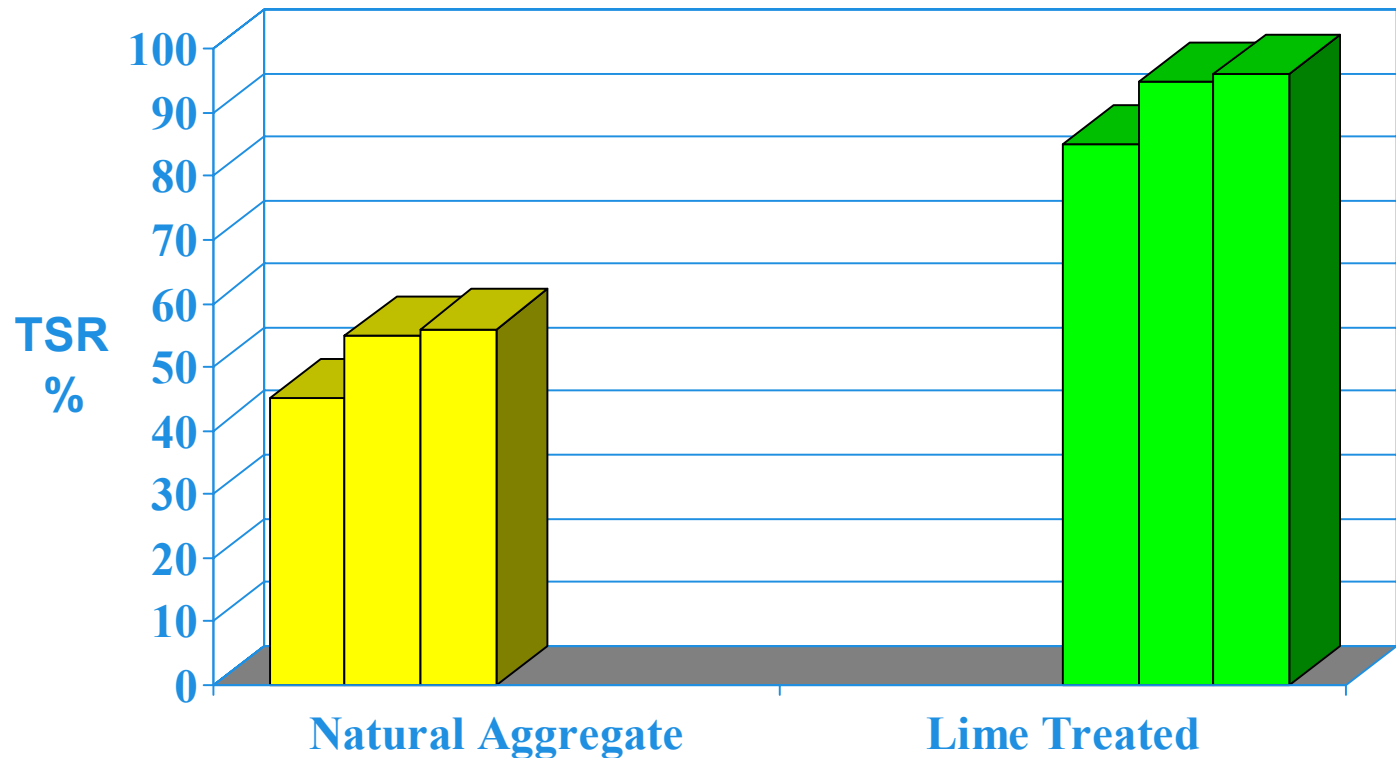
Moisture Sensitivity - Stripping

- **Adhesion - Poor stone/bitumen bond**
 - Problem aggregate types - siliceous, igneous
 - Incompatibility with bitumen
 - Mechanical loading – fatigue
 - Pore pressure & scour
- **Cohesion – Fracture within mastic**
 - Plastic deformation – rutting
 - Binder stiffness/ excessive loading
 - Environmental conditions – oxidative aging
 - Hardening >> fracture
- **Bitumen chemistry increasingly variable**

Benefits of Hydrated Lime

- **Chemically active filler**
 - Adhesion
 - Mitigate aggregate surface charge/bitumen conflict
 - Stiffen mix reducing effects of mechanical abrasion
 - 1% by aggregate weight often increases full PG grade
 - Cohesion
 - Reacts with polar molecules that promote stripping
 - Forms insoluble calcium salts
 - Fine particles intercept microcracks extending fatigue life

Moisture Sensitivity – Tensile Strength Ratio



T-283 results - three Mississippi aggregates

Influence of HL on Binder Stiffness

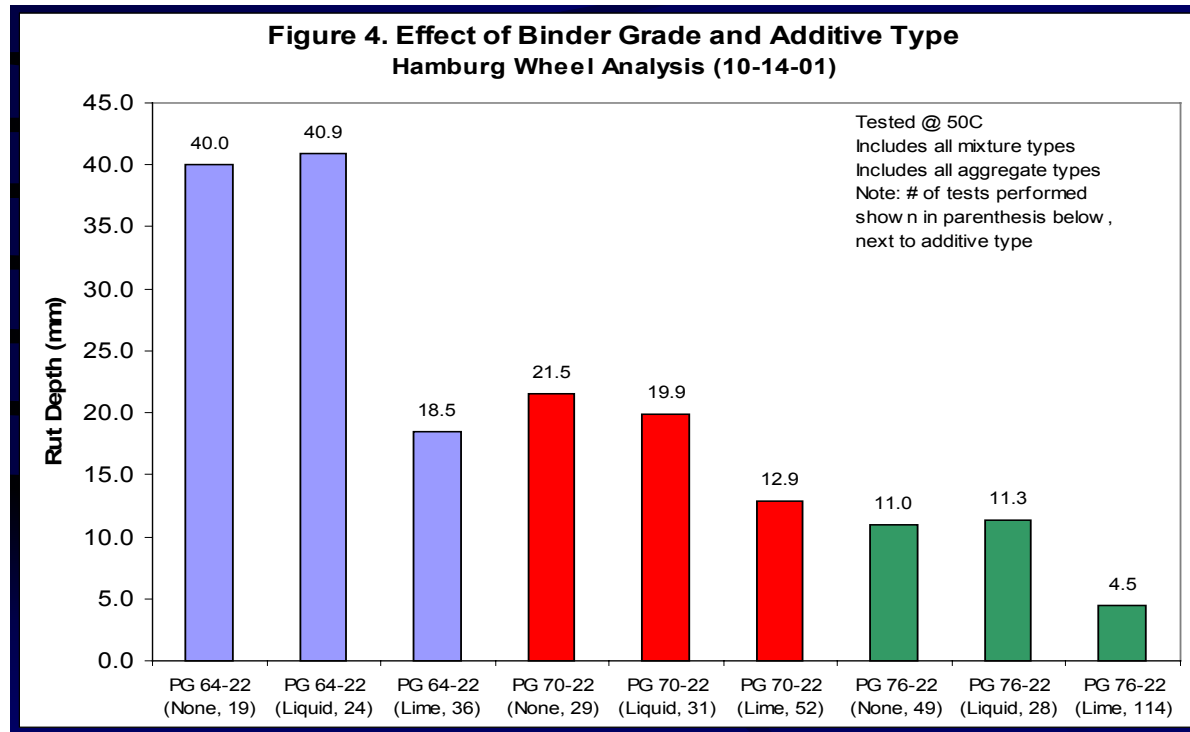


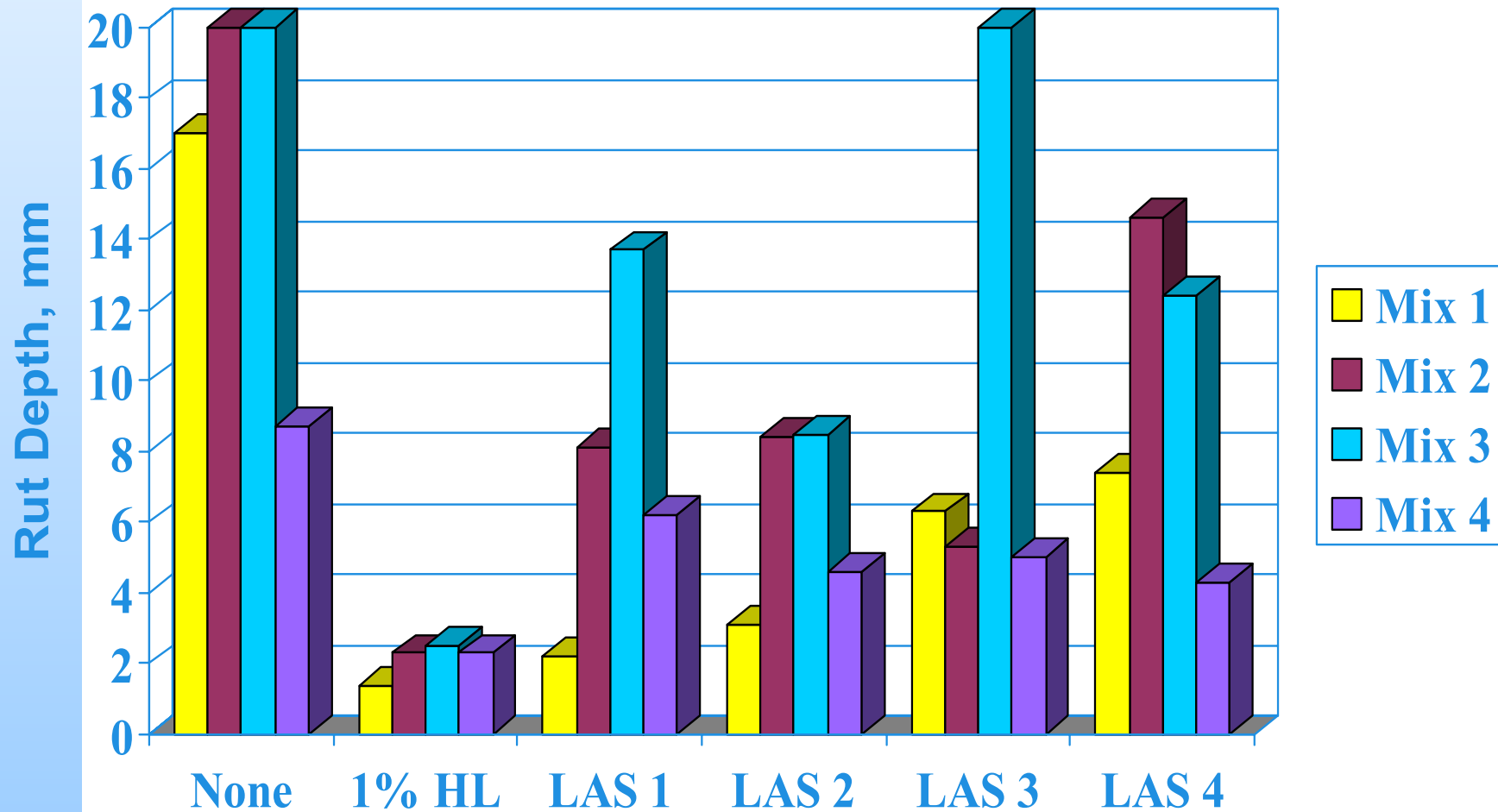
Table 6. Influence of Binder Type on Hamburg results

Binder	Additive	No. of Mixes	Rut Depth, mm
PG 64-22	None	19	40
	Lime	36	18.5
PG 70-22	None	29	21.5
	Lime	52	12.9
PG 76-22	None	49	11
	Lime	114	4.5

Source: Texas DOT/
Tahmoressi

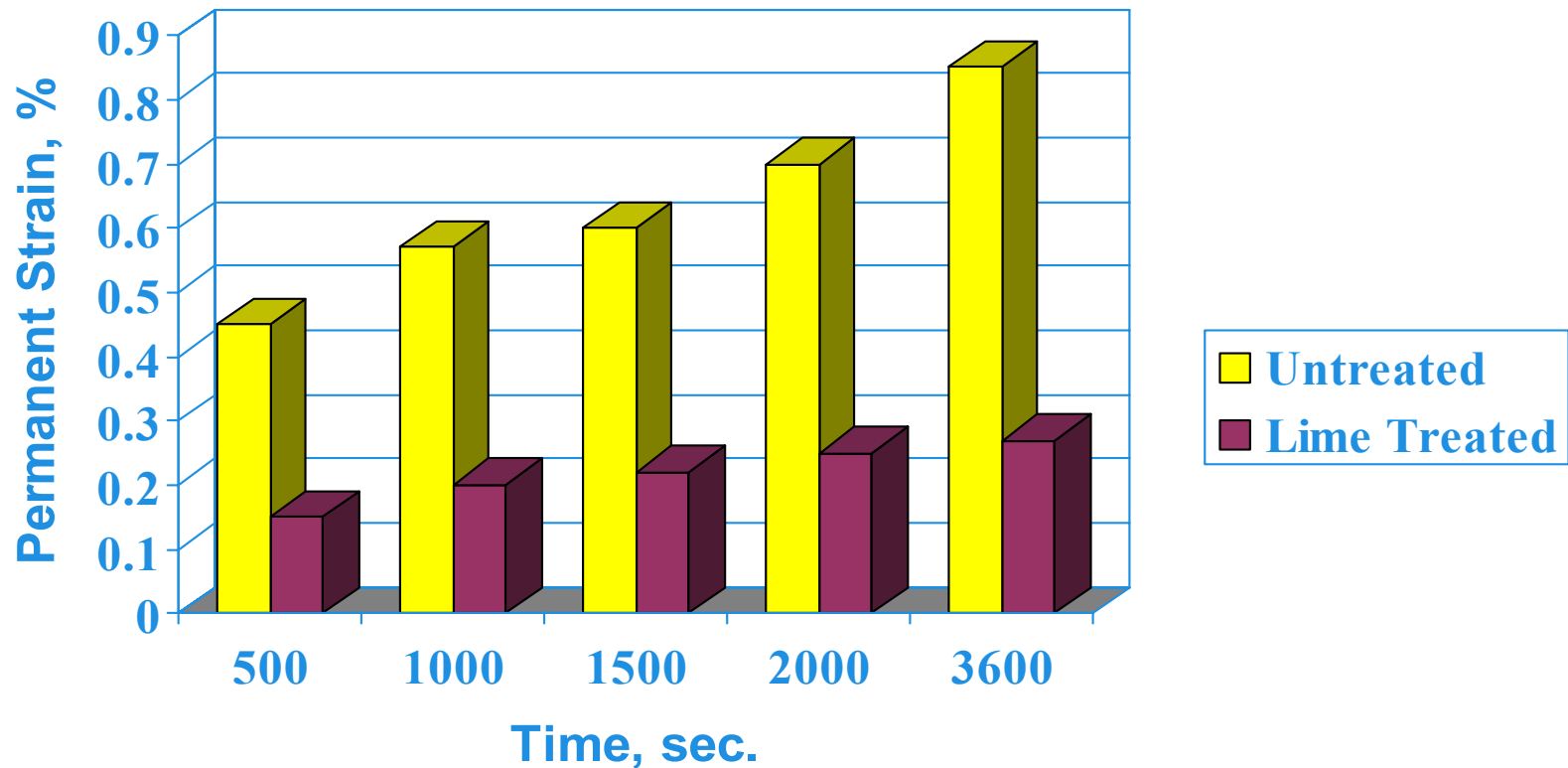
Hamburg Wheel Test

20,000 cycles (40°C)



Source: Colorado DOT

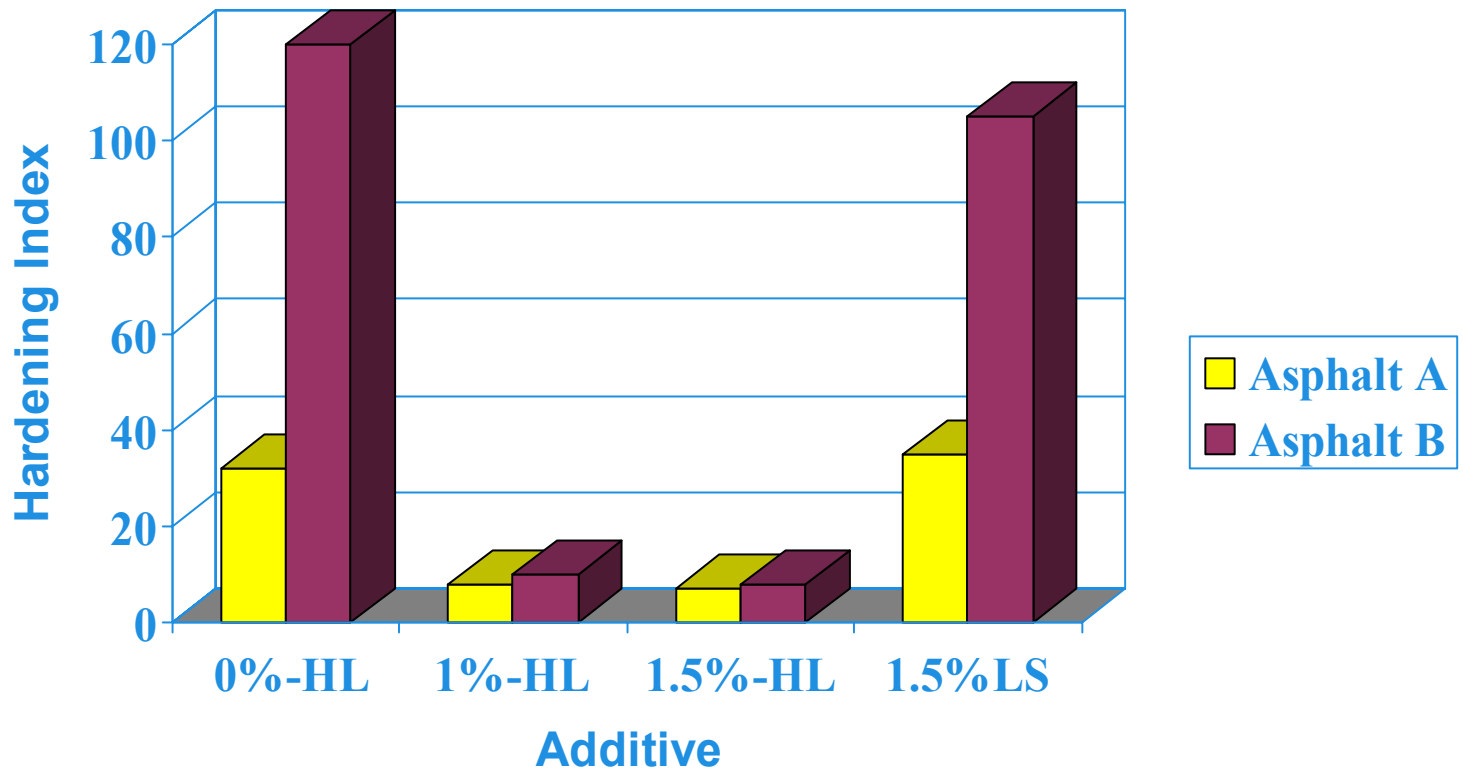
Permanent Strain/ Fracture Toughness



Bending Beam Rheometer (BBR)

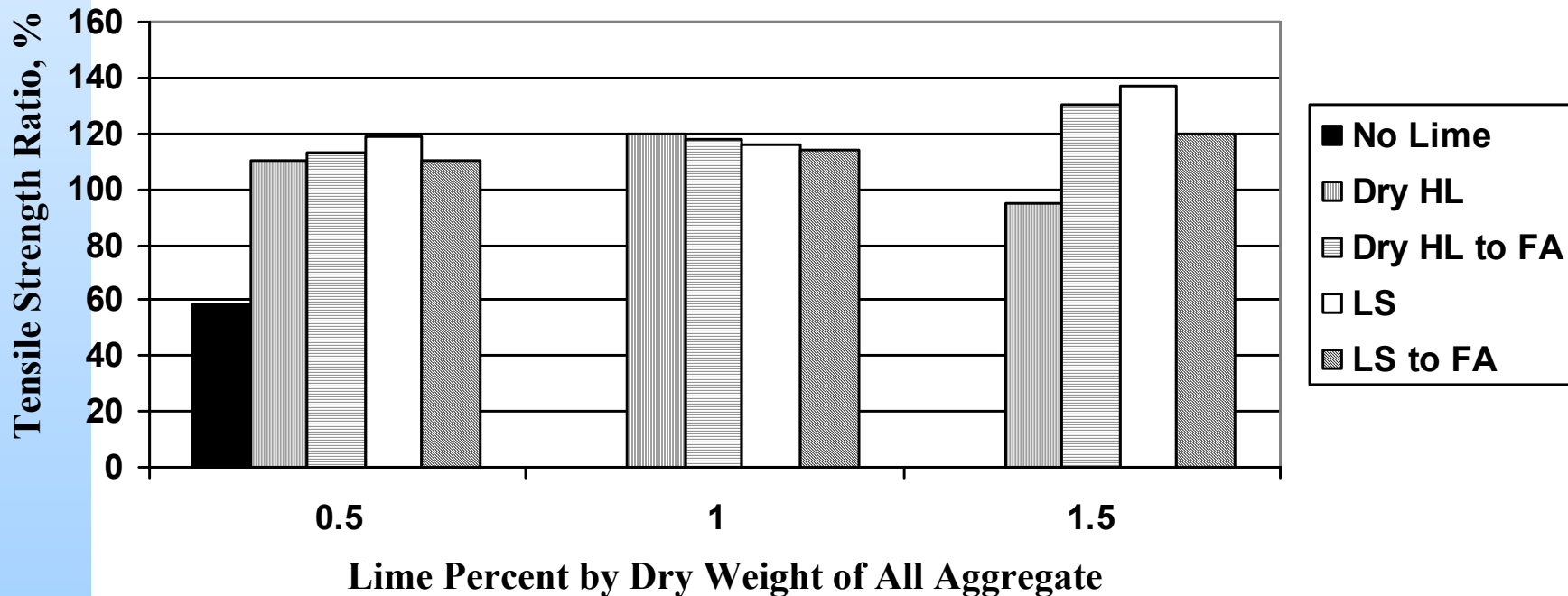
Source: Mississippi DOT

Effect of Lime on Age Hardening



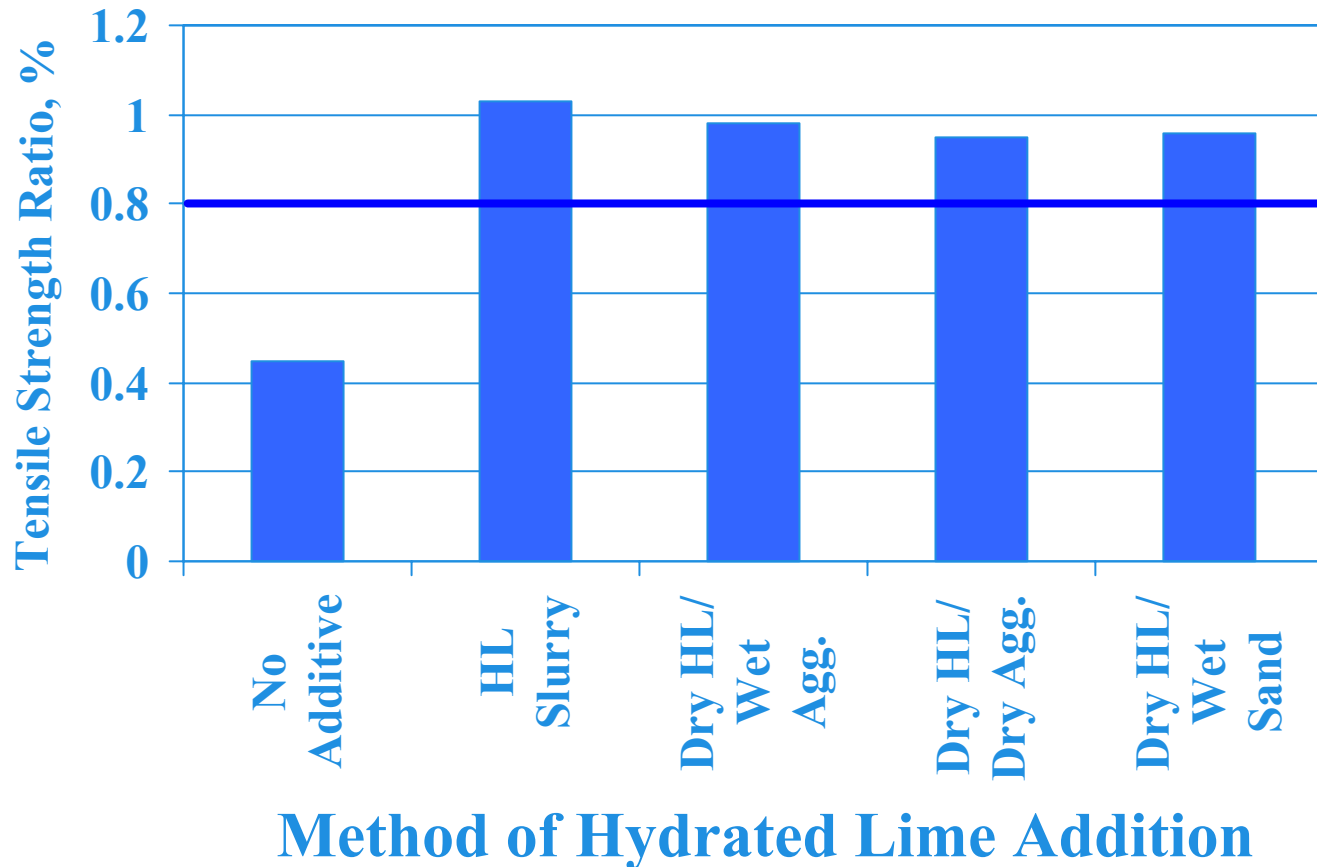
HL=hydrated lime; LS=limestone

Quantities of HL & Methods of Additon



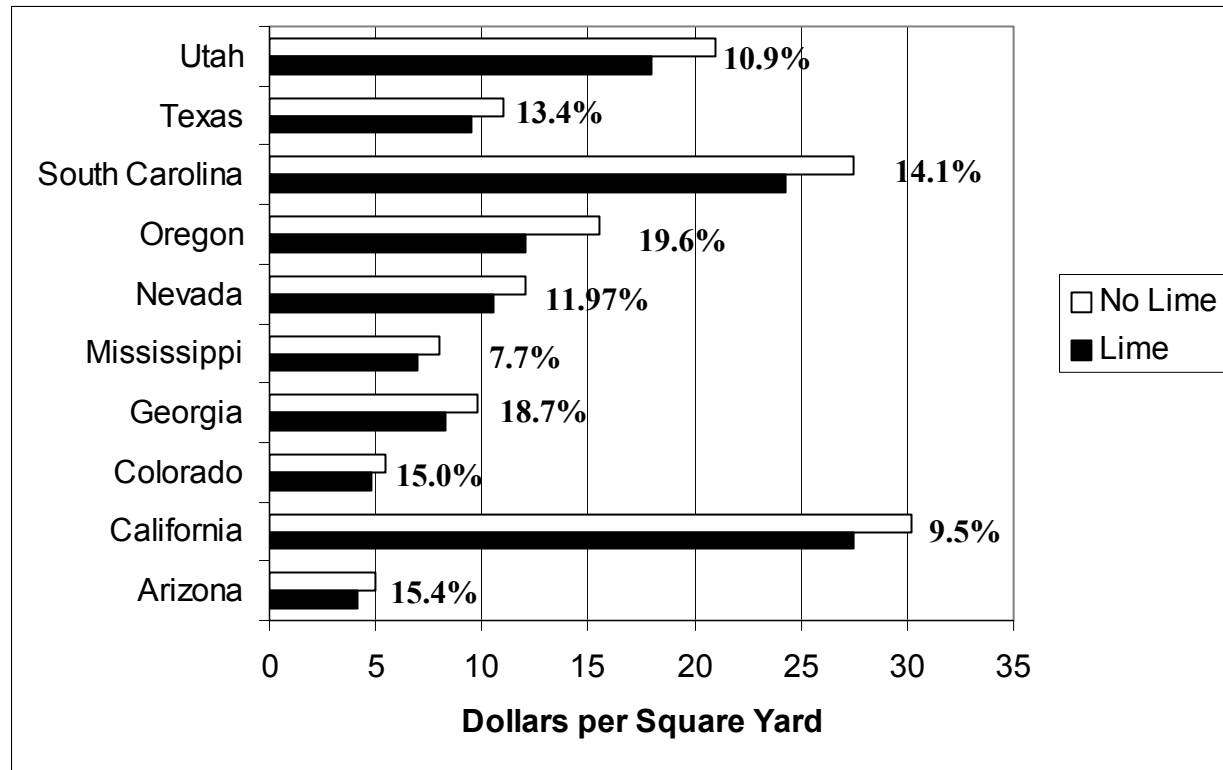
Effect of method of lime marination and percent lime added to granite aggregate
[after Hansen et al (1993), ref. 47]

Comparison of TSR



Source: Texas DOT

LCCA Cost Savings



Life cycle cost analysis of using lime for various states
[after Hicks et al. (2001), ref. 49]

Summary

- Hydrated lime improves performance of HMA
 - Moisture sensitivity
 - Rheology
- Moisture sensitivity
 - Proven best long term performer
 - Adhesion between mastic and stone
 - Improved viscosity - stiffness and resilience
- Rheology
 - Toughness at high and low temperatures
 - Active filler - captures polar molecules
 - Reduces oxidation and aging
- Synergistic benefits